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GLOBAL POSITIONING SYSTEM

Significant Challenges in Sustaining and Upgrading Widely Used Capabilities

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Highlights of [GAO-09-670T](#), a testimony before the Subcommittee on National Security and Foreign Affairs, Committee on Oversight and Government Reform, House of Representatives

Why GAO Did This Study

The Global Positioning System (GPS), which provides position, navigation, and timing data to users worldwide, has become essential to U.S. national security and a key tool in an expanding array of public service and commercial applications at home and abroad. The United States provides GPS data free of charge. The Air Force, which is responsible for GPS acquisition, is in the process of modernizing GPS.

In light of the importance of GPS, the modernization effort, and international efforts to develop new systems, GAO was asked to undertake a broad review of GPS. Specifically, GAO assessed progress in (1) acquiring GPS satellites, (2) acquiring the ground control and user equipment necessary to leverage GPS satellite capabilities, and evaluated (3) coordination among federal agencies and other organizations to ensure GPS missions can be accomplished. To carry out this assessment, GAO's efforts included reviewing and analyzing program documentation, conducting its own analysis of Air Force satellite data, and interviewing key officials.

What GAO Recommends

GAO recommended that the Secretary of Defense appoint a single authority to oversee the development of GPS, including space, ground control, and user equipment assets, to ensure these assets are synchronized and well executed, and potential disruptions are minimized. DOD concurred with our recommendations.

View [GAO-09-670T](#) or [key components](#). For more information, contact Cristina T. Chaplain at (202) 512-4841 or chaplain@gao.gov.

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What GAO Found

It is uncertain whether the Air Force will be able to acquire new satellites in time to maintain current GPS service without interruption. If not, some military operations and some civilian users could be adversely affected.

- In recent years, the Air Force has struggled to successfully build GPS satellites within cost and schedule goals; it encountered significant technical problems that still threaten its delivery schedule; and it struggled with a different contractor. As a result, the current IIF satellite program has overrun its original cost estimate by about \$870 million and the launch of its first satellite has been delayed to November 2009—almost 3 years late.
- Further, while the Air Force is structuring the new GPS IIIA program to prevent mistakes made on the IIF program, the Air Force is aiming to deploy the next generation of GPS satellites 3 years faster than the IIF satellites. GAO's analysis found that this schedule is optimistic, given the program's late start, past trends in space acquisitions, and challenges facing the new contractor. Of particular concern is leadership for GPS acquisition, as GAO and other studies have found the lack of a single point of authority for space programs and frequent turnover in program managers have hampered requirements setting, funding stability, and resource allocation.
- If the Air Force does not meet its schedule goals for development of GPS IIIA satellites, there will be an increased likelihood that in 2010, as old satellites begin to fail, the overall GPS constellation will fall below the number of satellites required to provide the level of GPS service that the U.S. government commits to. Such a gap in capability could have wide-ranging impacts on all GPS users, though there are measures the Air Force and others can take to plan for and minimize these impacts.

In addition to risks facing the acquisition of new GPS satellites, the Air Force has not been fully successful in synchronizing the acquisition and development of the next generation of GPS satellites with the ground control and user equipment, thereby delaying the ability of military users to fully utilize new GPS satellite capabilities. Diffuse leadership has been a contributing factor, given that there is no single authority responsible for synchronizing all procurements and fielding related to GPS, and funding has been diverted from ground programs to pay for problems in the space segment.

DOD and others involved in ensuring GPS can serve communities beyond the military have taken prudent steps to manage requirements and coordinate among the many organizations involved with GPS. However, GAO identified challenges in the areas of ensuring civilian requirements can be met and ensuring GPS compatibility with other new, potentially competing global space-based positioning, navigation, and timing systems.

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today to discuss the Global Positioning System (GPS)—a space-based satellite system that provides positioning, navigation, and timing data to users worldwide—that has become essential to U.S. national security and a key component in economic growth, transportation safety, homeland security, and critical national infrastructure in the United States and abroad. In view of the importance of GPS to the military, the economy and other critical sectors, and problems being experienced in the acquisition of GPS, you requested that we perform a comprehensive review of the program. Our report, which was issued on April 30, presents our findings in considerable detail. My statement today will focus on the essence of what we found.

In summary, it is uncertain whether the Air Force will be able to acquire new satellites in time to maintain current GPS service without interruption. If not, some military operations and some civilian users could be adversely affected. In addition, military users will experience a delay in utilizing new GPS capabilities, including improved resistance to jamming of GPS signals, because of poor synchronization of the acquisition and development of the satellites with the ground control and user equipment. Finally, there are challenges in ensuring civilian requirements for GPS can be met and that GPS is compatible with other new, potentially competing global space-based positioning, navigation, and timing systems.

Background

The U.S. government provides GPS service free of charge and plans to invest more than \$5.8 billion over the next 5 years in the GPS satellites and ground control segments. The Department of Defense (DOD) develops and operates GPS, and an interdepartmental committee—co-chaired by DOD and the Department of Transportation—manages the U.S. space-based positioning, navigation, and timing infrastructure, which includes GPS. DOD also provides most of the funding for GPS. The Air Force is responsible for GPS acquisition and is in the process of modernizing GPS to enhance its performance, accuracy, and integrity. The modernization effort includes GPS IIF and IIIA, two satellite acquisition programs that are to provide new space-based capabilities and replenish the satellite constellation; the ground control segment hardware and software; and user equipment for processing modernized GPS capabilities. Other countries are also developing their own independent global navigation satellite systems that could offer capabilities that are comparable, if not superior, to GPS.

Air Force Faces Significant Challenges in Acquiring GPS Satellites

In recent years under the IIF program, the Air Force has struggled to successfully build GPS satellites within cost and schedule goals. It encountered significant technical problems that still threaten its delivery schedule and it struggled with a different contractor for the IIF program. These problems were compounded by an acquisition strategy that relaxed oversight and quality inspections as well as multiple contractor mergers and moves, and the addition of new requirements late in the development cycle.

GPS was not the only space program started in the 1990s to face such challenges. In fact, DOD continues to face cost overruns in the billions of dollars, schedule delays adding up to years, and performance shortfalls stemming from programs that began in the 1990s and after that were poorly structured, managed and overseen. What sets GPS apart from those programs is that GPS had already been “done” before. The GPS IIF program was far less ambitious than efforts to advance missile warning and weather monitoring capabilities, for example.

Our report documents the history of the IIF program and the decisions made early on that weakened the foundation for program execution. What is important to highlight today is that the program is still experiencing technical problems that still threaten its delivery schedule. For example, last year, during the first phase of thermal vacuum testing (a critical test to determine space-worthiness that subjects the satellite to space-like operating conditions), one transmitter used to send the navigation message to the users failed. The program suspended testing in August 2008 to allow time for the contractor to identify the causes of the problems and take corrective actions. The program also had difficulty maintaining the proper propellant fuel-line temperature; this, in addition to power failures on the satellite, delayed final integration testing. In addition, the satellite’s reaction wheels, used for pointing accuracy, were redesigned because on-orbit failures on similar reaction wheels were occurring on other satellite programs—this added about \$10 million to the program’s cost. As a result of these problems, the cost to complete GPS IIF will be about \$1.6 billion—about \$870 million over the original cost estimate of \$729 million. The launch of the first IIF satellite has been delayed until November 2009—almost 3 years late.

The Air Force is taking measures to prevent the problems experienced on the GPS IIF program from recurring on the GPS IIIA program. Some of the measures the Air Force is taking include:

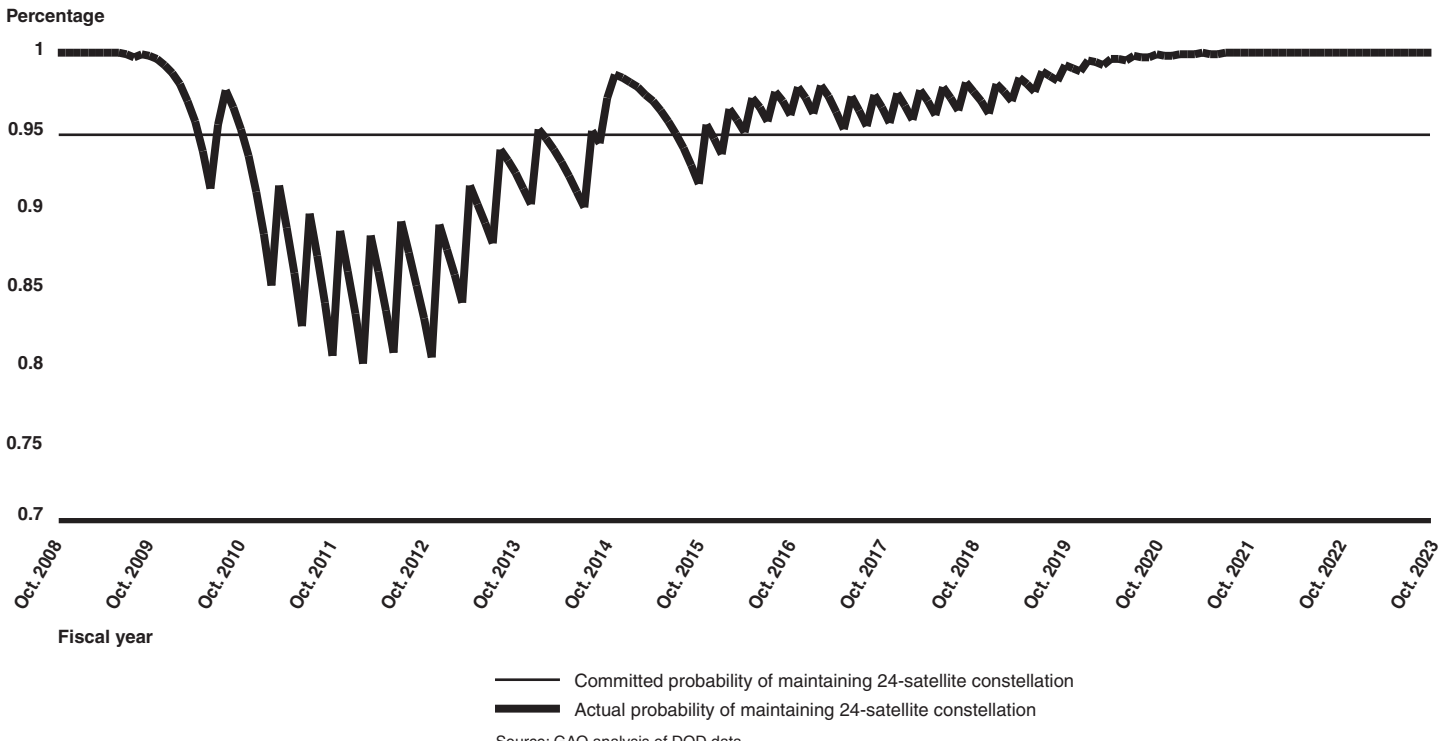
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- using incremental or block development, where the program would follow an evolutionary path toward meeting needs rather than attempting to satisfy all needs in a single step;
 - using military standards for satellite quality;
 - conducting multiple design reviews, with the contractor being held to military standards and deliverables during each review;
 - exercising more government oversight and interaction with the contractor and spending more time at the contractor's site;
 - using an improved risk management process, where the government is an integral part of the process;
 - not allowing the program manager to adjust the GPS IIIA program scope to meet increased or accelerated technical specifications, system requirements, or system performance; and
 - conducting an independent technology readiness assessment of the contractor design once the preliminary design review is complete.

These efforts are not trivial. The primary causes of space acquisition problems in our view include (1) the tendency to start space programs too early, that is, before there has been assurance that the capabilities being pursuing can be achieved within resources and time constraints and (2) the tendency to attempt to achieve all requirements in one step rather than gradually. The GPS IIIA program was structured to avoid these problems and ensure the program has the right knowledge for moving forward into the acquisition process. Moreover, our work has cited prior acquisition strategies in which the lack of contractor oversight was a problem. Again, the actions being taken on GPS IIIA put controls in place to strengthen oversight and government involvement. We also recognize that the GPS IIIA program took steps to produce realistic cost estimates, which has generally not been done in the past.

Nevertheless, there is still a high risk that the Air Force will not meet its schedule for GPS. First, it is aiming to deploy the GPS IIIA satellites 3 years faster than the IIF satellites. Second, the time period between the contract award and first launch for GPS IIIA is shorter than most other major space programs we have reviewed. Third, GPS IIIA is not simply a matter of replicating the IIF program. Though the contractor has had previous experience with GPS, it is likely that the knowledge base will need to be revitalized. The contractor is also being asked to develop a larger satellite bus to accommodate the future GPS increments and to increase the power of a new military signal by a factor of ten. In view of these and other schedule issues, we believe that there is little room in the schedule to accommodate difficulties that the contractor or program may face.

Where does this leave the wide span of military, civil, and other user of GPS? If the Air Force does not meet its schedule goals for development of GPS IIIA satellites, there will be an increased likelihood that in 2010, as old satellites begin to fail, the overall GPS constellation will fall below the number of satellites required to provide the level of GPS service that the U.S. government is committing to providing. The performance standards for both (1) the standard positioning service provided to civil and commercial GPS users and (2) the precise positioning service provided to military GPS users commit the U.S. government to at least a 95 percent probability of maintaining a constellation of 24 operational GPS satellites. Because there are currently 31 operational GPS satellites of various blocks, the near-term probability of maintaining a constellation of at least 24 operational satellites remains well above 95 percent. However, DOD predicts that over the next several years many of the older satellites in the constellation will reach the end of their operational life faster than they will be replenished, and that the constellation will, in all likelihood, decrease in size. Based on the most recent satellite reliability and launch schedule data approved in March 2009, the estimated long-term probability of maintaining a constellation of at least 24 operational satellites falls below 95 percent during fiscal year 2010 and remains below 95 percent until the end of fiscal year 2014, at times falling to about 80 percent. See figure 1 for details.

Figure 1: Probability of Maintaining a Constellation of at Least 24 GPS Satellites Based on Reliability Data and Launch Schedule as of March 2009



Such a gap in capability could have wide-ranging impacts on GPS users, though the exact impact is hard to precisely define, as it would depend on which satellites stop operating. To illustrate, however, the military could see a decrease in the accuracy of precision-guided munitions that rely on GPS to strike their targets. Disruptions in service could require military forces to either use larger munitions or to use more munitions on the same target to achieve the same level of success. Intercontinental commercial flights use predicted satellite geometry over their planned navigation route, and may have to delay, cancel, or reroute flights. Enhanced 911 services, which rely on GPS to precisely locate callers, could lose accuracy particularly when operating in urban canyons or mountainous terrain.

The Air Force is aware that, over the next several years, there is some risk that the number of satellites in the GPS constellation could fall below its required 24 satellites, and that this risk would grow significantly if the development and launch of GPS IIIA satellites were delayed by several

years. Consequently, Air Force Space Command has established an independent review team to examine the risks and consequences of a smaller constellation on military and civil users. There are measures the Air Force and others can take to plan for and minimize these impacts, which are detailed in our report. However, at this time Air Force representatives believe the best approach to mitigating the risk is to take all reasonable steps to ensure that the current schedule for GPS IIIA is maintained. Moreover, it is unclear whether the user community knows enough about the potential problem to do something about it.

New Satellite Capabilities Will Not Be Leveraged Because of Delayed Delivery of Ground and User Equipment Capabilities

To maximize the benefit of GPS, the delivery of its ground control and user equipment capabilities must be synchronized with the delivery of the satellites so that the full spectrum of military assets and individual users can take advantage of new capabilities. This is a challenging endeavor for GPS as it involves installing GPS equipment on board a wide range of ships, aircraft, missiles, and other weapon systems. Our review found that because of funding shifts and diffuse leadership, the Air Force has not been successful in synchronizing satellite, ground control, and user equipment segments. As a result of the poor synchronization, new GPS capabilities may be delivered in space for years before military users can take advantage of them.

The Air Force used funding set aside for the ground control and user equipment segment to resolve GPS satellite development problems, causing a delay in the delivery of new GPS capabilities. For example, in 2005 the Air Force began launching its GPS IIR-M satellites, which broadcast a second civil signal. Unfortunately, the ground control segment will not be able to make the second civil signal operational until late 2012 or 2013—7 years later. Likewise, a modernized military signal designed to improve resistance to jamming of GPS will be available for operations on GPS satellites over a decade before user equipment will be fielded that is able to take strategic advantage of it.

Because leadership for acquisitions across the space community is fragmented, there is no single authority responsible for synchronizing all segments related to GPS. The responsibility for developing and acquiring GPS satellites and associated ground control segments and for acquiring and producing user equipment for selected platforms for space, air, ground, and maritime environments falls under the Air Force's Space and Missile Systems Center. On the other hand, responsibility for acquiring and producing user equipment for all other platforms falls on the military services.

Challenges in Coordinating Requirements and Ensuring Compatibility

GPS has produced dramatic improvements both for the United States and globally. Ensuring that it can continue to do so is extremely challenging given competing interests, the span of government and commercial organizations involved with GPS, and the criticality of GPS to national and homeland security and the economy. On the one hand, DOD must ensure that military requirements receive top priority and the program stays executable. In doing so, it must ensure that the program is not encumbered by requirements that could disrupt development, design, and production of satellites. On the other hand, there are clearly other enhancements that could be made to GPS satellites that could serve a variety of vital missions—particularly because of the coverage GPS satellites provide—and there is an expressed desire for GPS to serve as the world’s preeminent positioning, navigation, and timing system. In addition, while the United States is challenged to deliver GPS on a tight schedule, other countries are designing and developing systems that provide the same or enhanced capabilities. Ensuring that these capabilities can be leveraged without compromising national security or the preeminence of GPS is also a delicate balancing act that requires close cooperation between DOD, the Department of State, and other institutions.

Because of the scale and number of organizations involved in maximizing GPS, we did not undertake a full-scale review of the requirements and coordination processes. However, we reviewed documents supporting these processes and interviewed a variety of officials to obtain views on their effectiveness. While there is a consensus that DOD and other federal organizations involved with GPS have taken prudent steps to manage requirements and optimize GPS use, we also identified challenges in the areas of ensuring civilian requirements can be met and ensuring that GPS is compatible with other new, potentially competing global space-based positioning, navigation, and timing systems. According to the civil agencies that have proposed GPS requirements, the formal requirements approval process is confusing, time consuming, and difficult to manage. Regarding the international community, while the U.S. government has engaged a number of other countries and international organizations in cooperative discussions, only one legally binding agreement has been established.

Stronger Leadership Paramount to Addressing GPS Problems

GPS has enabled transformations in military and other government operations and has become part of the critical infrastructure serving national and international communities. Clearly, the United States cannot afford to see its GPS capabilities decrease below its requirement, and optimally, it is one that should stay preeminent. Over the past decade, however, the program has experienced cost increases and schedule delays, and though the Air Force is making a concerted effort to address acquisition problems, there is still considerable risk that satellites will not be delivered on time and that there will be gaps in capability.

As such, we concluded in our review that focused attention and oversight is needed to ensure the program stays on track and is adequately resourced, that unanticipated problems are quickly discovered and resolved, and that all communities involved with GPS are aware of and positioned to address potential gaps in service. But this is difficult to achieve given diffuse responsibility for the GPS acquisition program. Importantly, several recent congressional studies have found that authority and responsibilities for military space and intelligence programs are scattered across the staffs of various DOD organizations and the Intelligence Community, and that this is contributing to difficulties on all major space programs in meeting their schedules.

The problem is more acute with GPS because of the range of organizations involved in the program. As mentioned earlier, because different military services are involved in developing and installing equipment onto the weapon systems they operate, there are separate budget, management, oversight, and leadership structures over the user segments. And while there have been various recommendations to accelerate the fielding of military user equipment, this has been difficult to do partially because the program office is experiencing technical issues.

We recommended that the Secretary of Defense appoint a single authority to oversee the development of the GPS system, including space, ground control, and user equipment assets, to ensure that the program is well executed and resourced and that potential disruptions are minimized. The appointee should have authority to ensure space, ground control, and user equipment are synchronized to the maximum extent practicable; and coordinate with the existing positioning, navigation, and timing infrastructure to assess and minimize potential service disruptions in the event that the satellite constellation were to decrease in size for an extended period of time. Given the importance of GPS to the civil community, we also recommended that the secretaries of Defense and Transportation, as the co-chairs of the National Executive Committee for

Space-Based Positioning, Navigation and Timing, address, if weaknesses are found, civil agency concerns for developing requirements and determine mechanisms for improving collaboration and decision making and strengthening civil agency participation.

In responding to our report, DOD concurred with our recommendations, and stated that it recognized the importance of centralizing authority to oversee the continuing synchronized evolution of the GPS and that it will continue to seek ways to improve civil agency understanding of the DOD requirements process and work to strengthen civil agency participation. We continue to believe that DOD will consider an approach that enables a single individual to make resource decisions and maintain visibility over progress and establish a means by which progress in developing the satellites and ground equipment receive attention from the highest level of leadership, that is the Defense Secretary and perhaps the National Security Council, given the criticality of GPS to the warfighter and the nation, and the risks associated with not meeting schedule goals. In addition, as DOD undertakes efforts to inform and educate civil agencies on the requirements process, we encourage it to take a more active role in directly communicating with civil agencies to more precisely identify concerns or weaknesses in the requirements process.

Mr. Chairman, this concludes my statement. I will be happy to answer any questions that you or other Members of the Subcommittee have at this time.

Appendix I: Scope and Methodology

To assess the acquisition of satellite, ground control, and user equipment, we interviewed Office of the Secretary of Defense (OSD) and Department of Defense (DOD) officials from offices that manage and oversee the Global Positioning System (GPS) program. We also reviewed and analyzed program plans and documentation related to cost, schedule, requirements, program direction, and satellite constellation sustainment, and compared programmatic data to GAO's criteria compiled over the last 12 years for best practices in system development. We also conducted our own analysis, based on data provided by the Air Force, to assess the implications of potential schedule delays we identified in our assessment of the satellite acquisition. To assess coordination among federal agencies and the broader GPS community, we interviewed OSD and DOD officials from offices that manage and oversee the GPS program, officials from the military services, officials from civil departments and agencies, and officials at the U.S. Department of State and at various European space organizations. We also analyzed how civil departments and agencies coordinate with DOD on GPS civil requirements, and how the U.S. government coordinates with foreign countries. We conducted this performance audit from October 2007 to April 2009 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Contact and Acknowledgments

For further information, please contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov. Individuals making contributions to this testimony include Art Gallegos, Greg Campbell, Maria Durant, Laura Hook, Sigrid McGinty, Jay Tallon, and Alyssa Weir.

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